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(58) Field of Search:
INT CL **B64C, B64G**
Other: **WPI; EPODOC**

(54) Title of the Invention: **A flight system**
Abstract Title: **A wearable flight system with hand mounted propulsion assemblies**

(57) A wearable flight system 300 has a number of propulsion assemblies 100,200 including a left-hand propulsion assembly 2 and a right-hand propulsion assembly 1 worn on a user's hands and/or forearm. Preferably a body propulsion assembly 200 is provided with a support 6 for a user's waist or torso. The support may be worn on the users back or waist and connect the body propulsion assembly below the user's waist. Leg propulsion assemblies (fig.5d,400) may also be provided. The propulsion assemblies may use a number of turbines and/or ducted electric fans set at angles to one another delivering non-parallel thrust vectors. The hand propulsion assemblies are worn such that net thrust is directed in line with the users arm, away from their elbow. Preferably, the hand propulsion assemblies collectively provide at least 800N maximum thrust, this may be greater than the maximum thrust of at least 400N provided by the body propulsion assembly. The system may also include an inflatable fuel storage bladder connected to the propulsion assemblies via a fuel line. A sensor may alert the user to the presence of bubbles in the fuel line. The hand propulsion systems may be freely movable relative to one another; alternatively, an actuated articulated frame 23 may be provided, limiting the range of movement.

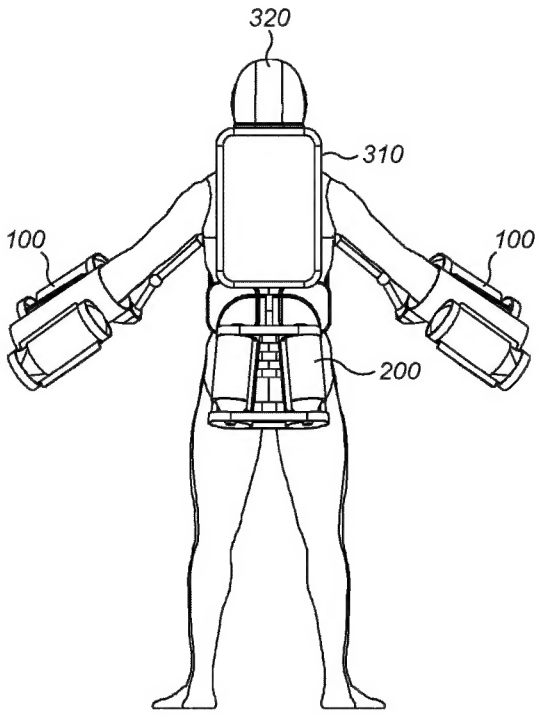

FIG. 3c

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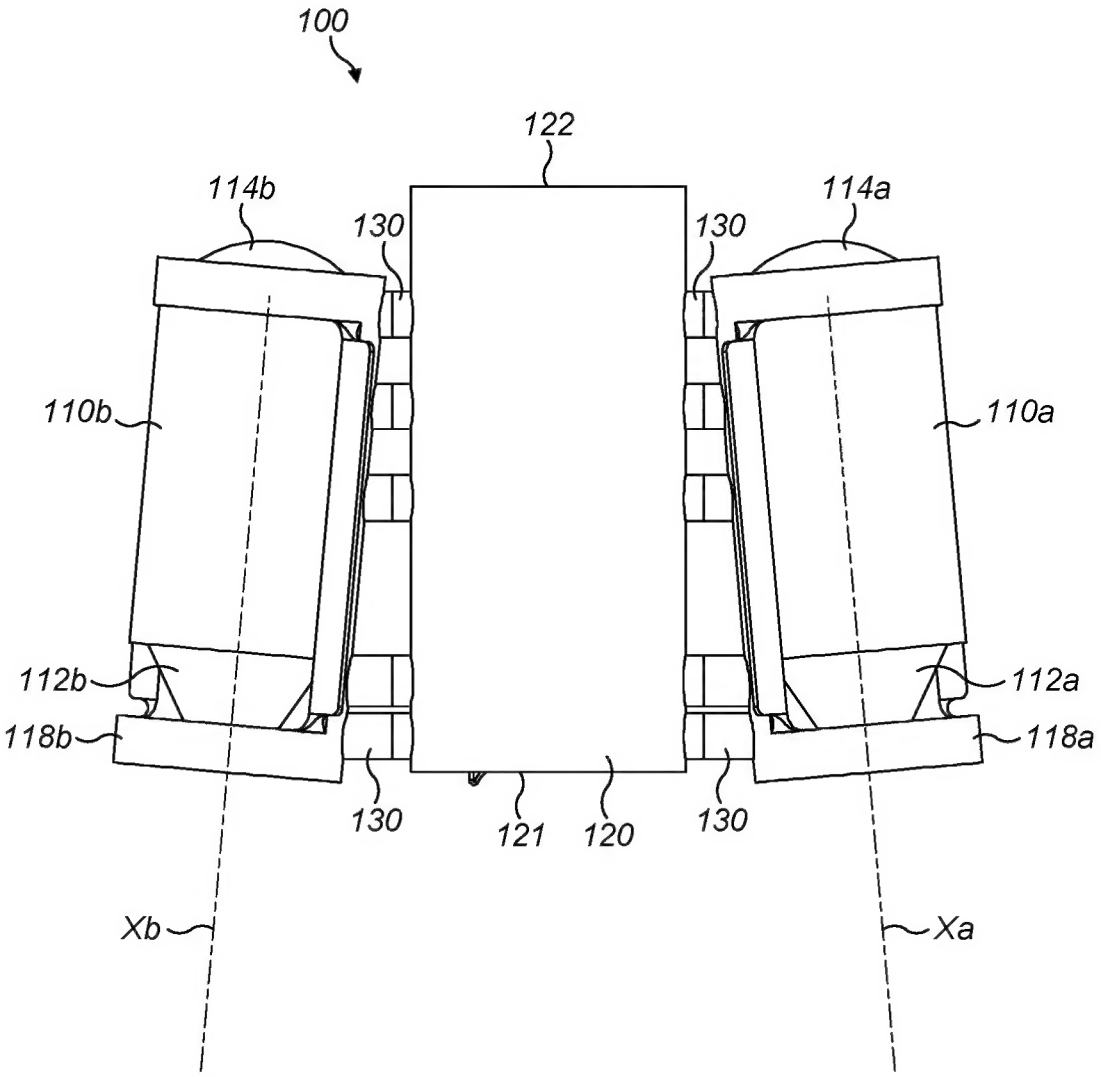

FIG. 1a

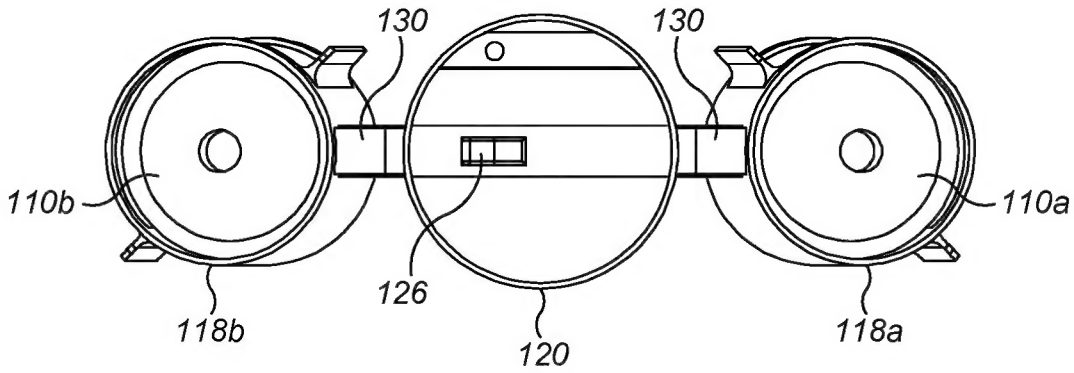

FIG. 1b

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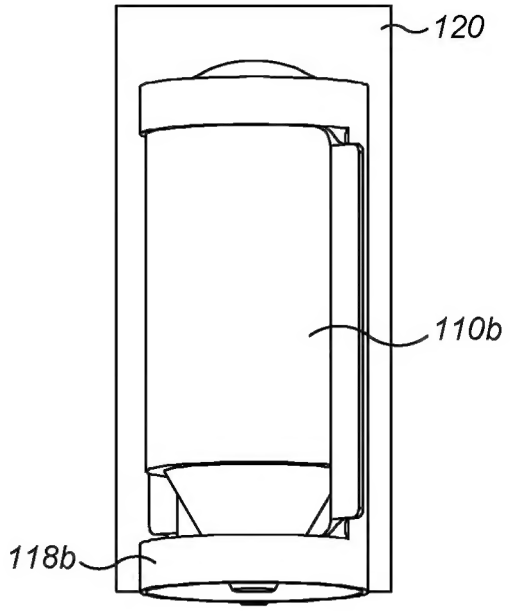

FIG. 1c

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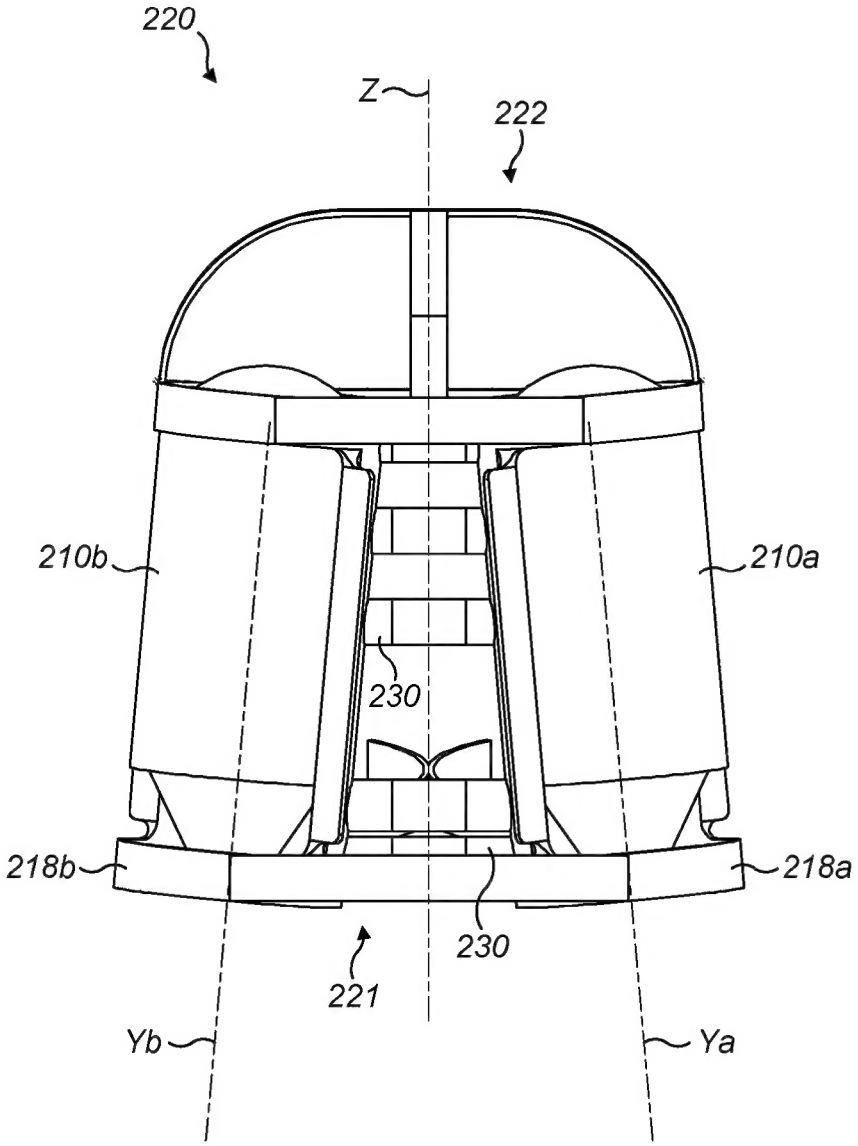

FIG. 2a

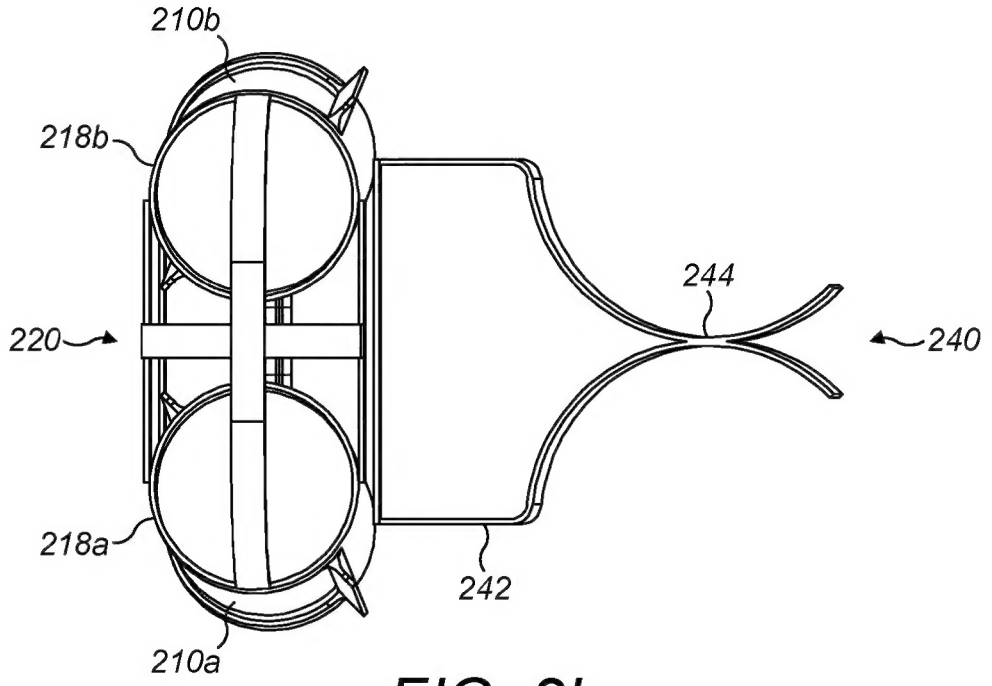

FIG. 2b

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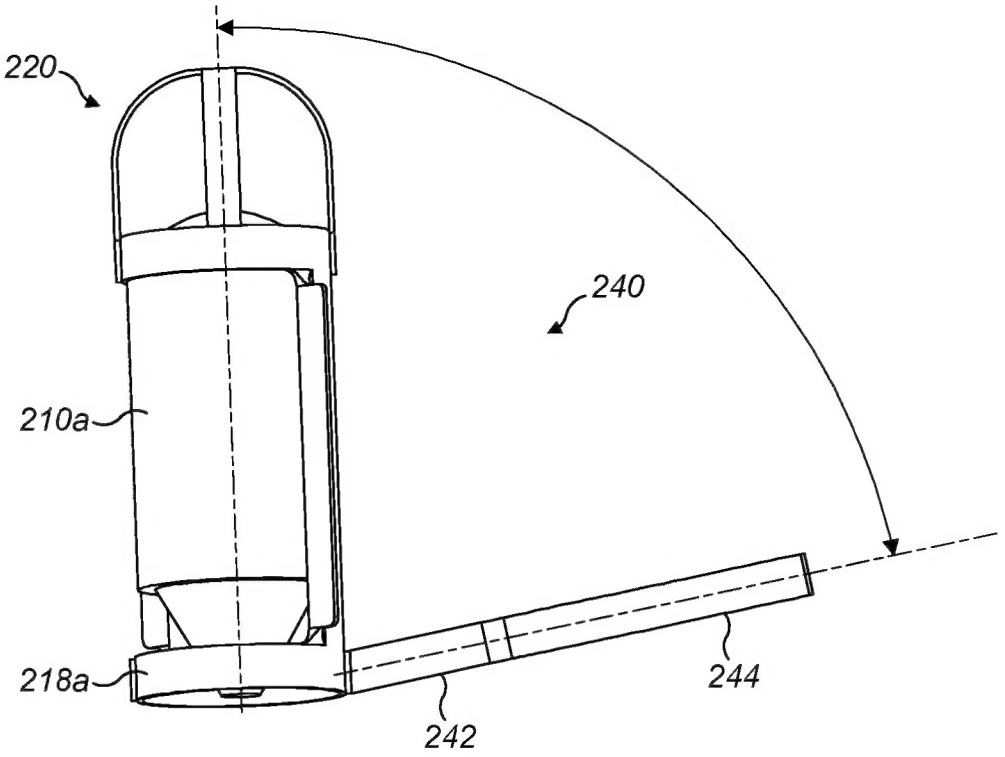

FIG. 2c

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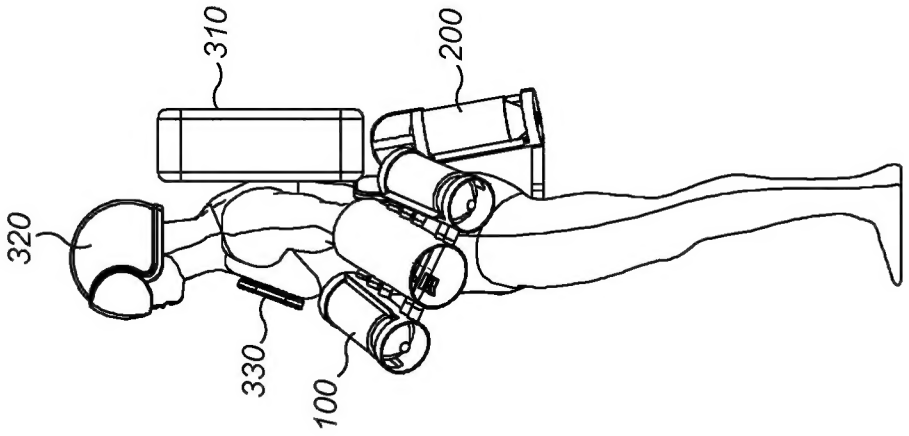

FIG. 3b

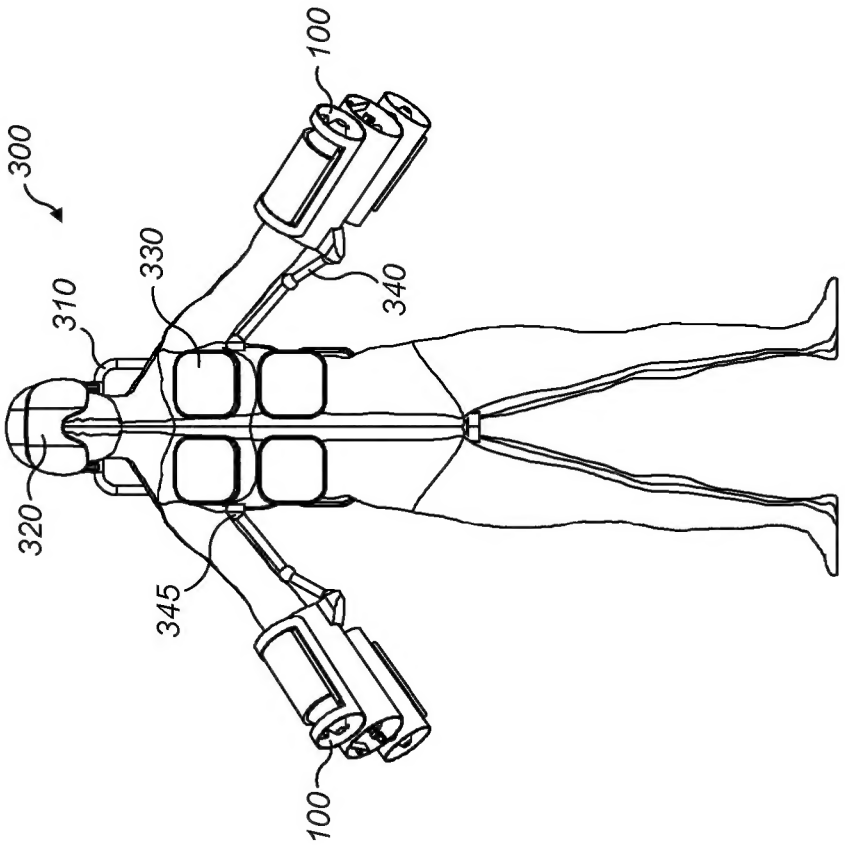

FIG. 3a

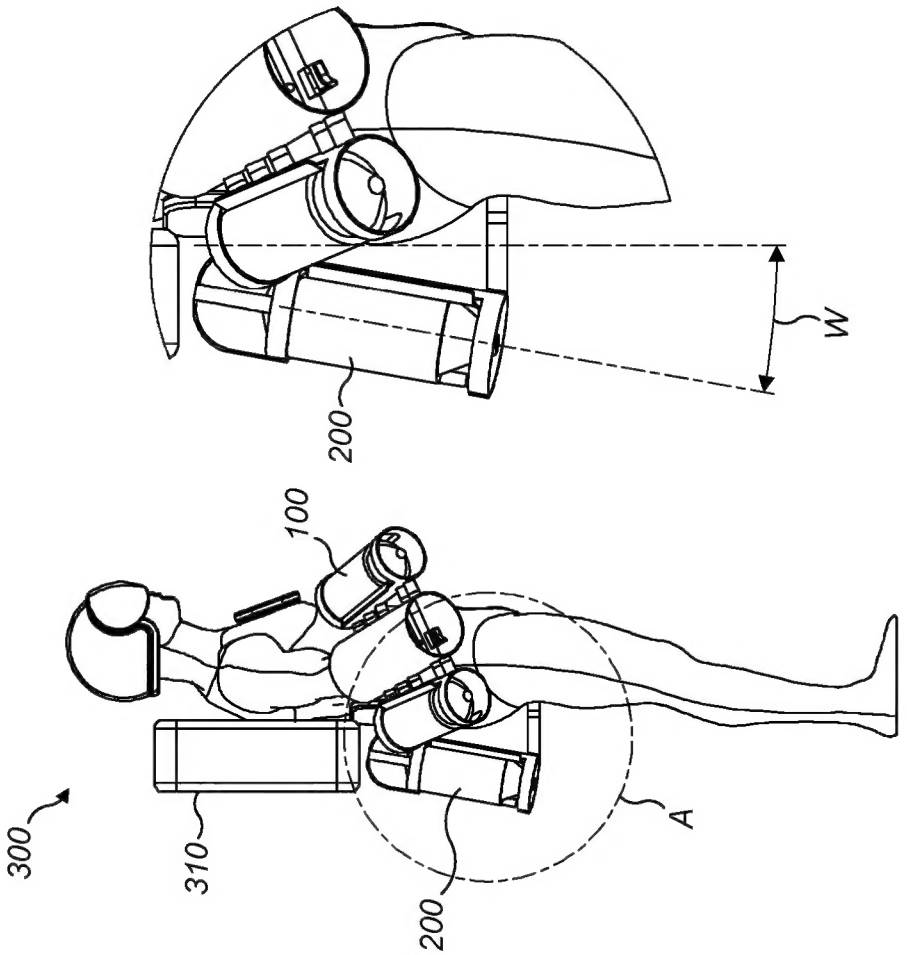

FIG. 3d

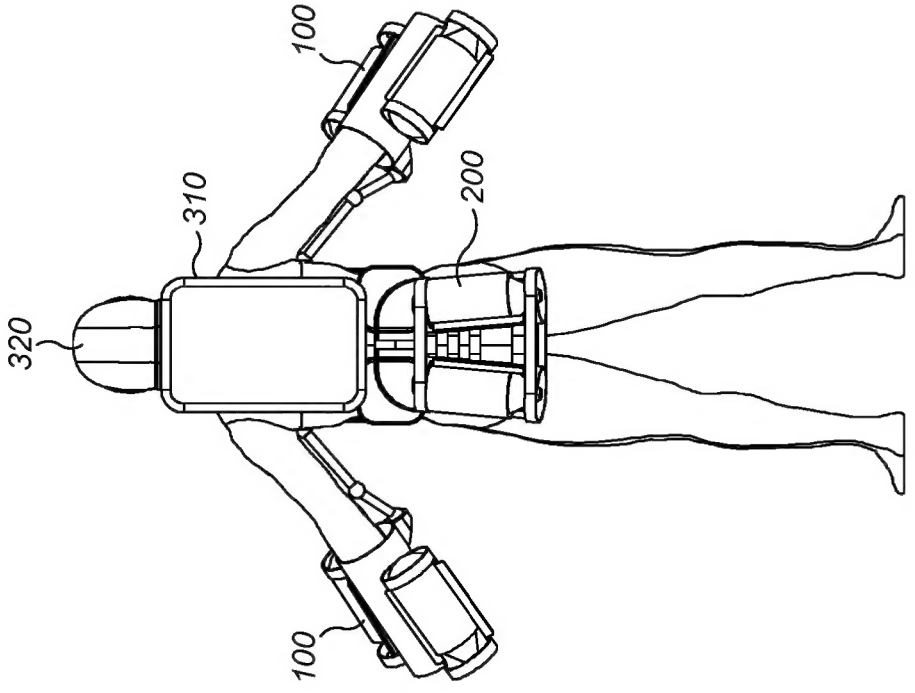

FIG. 3c

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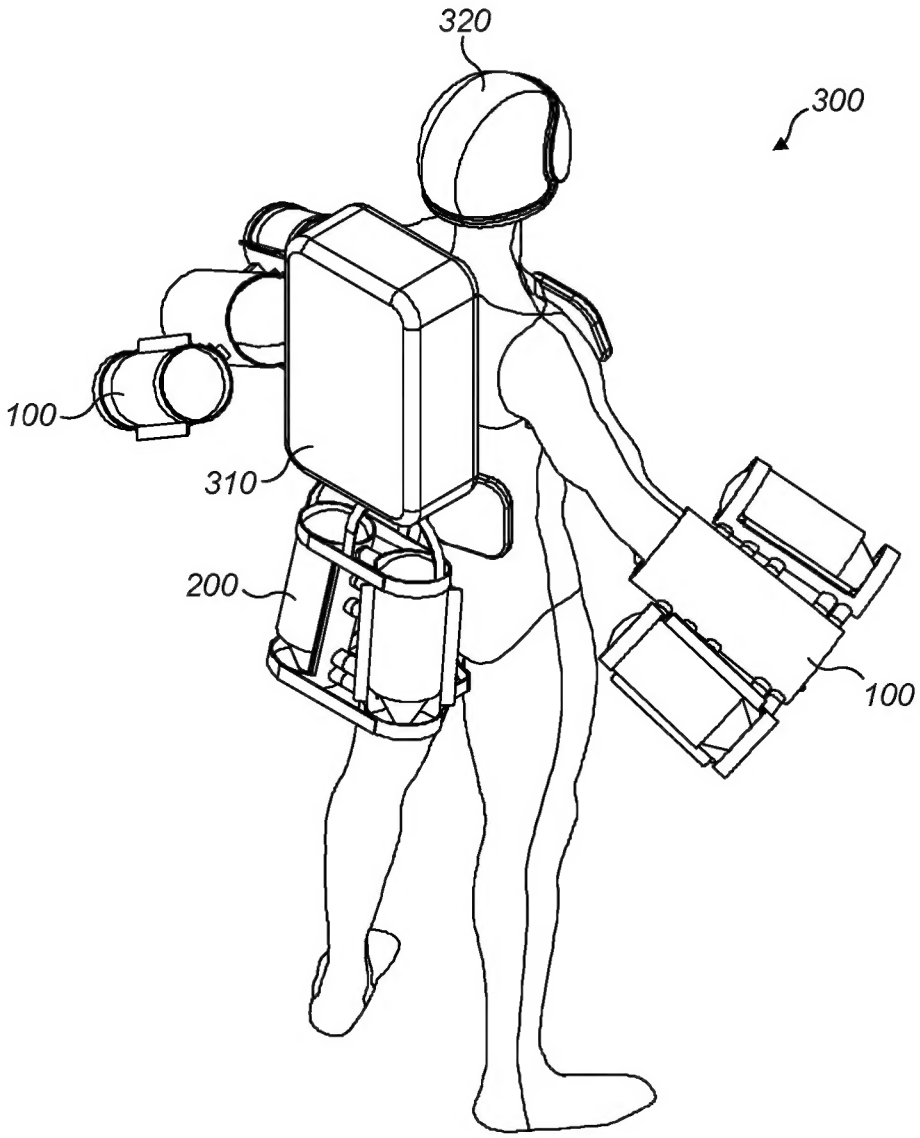

FIG. 3e

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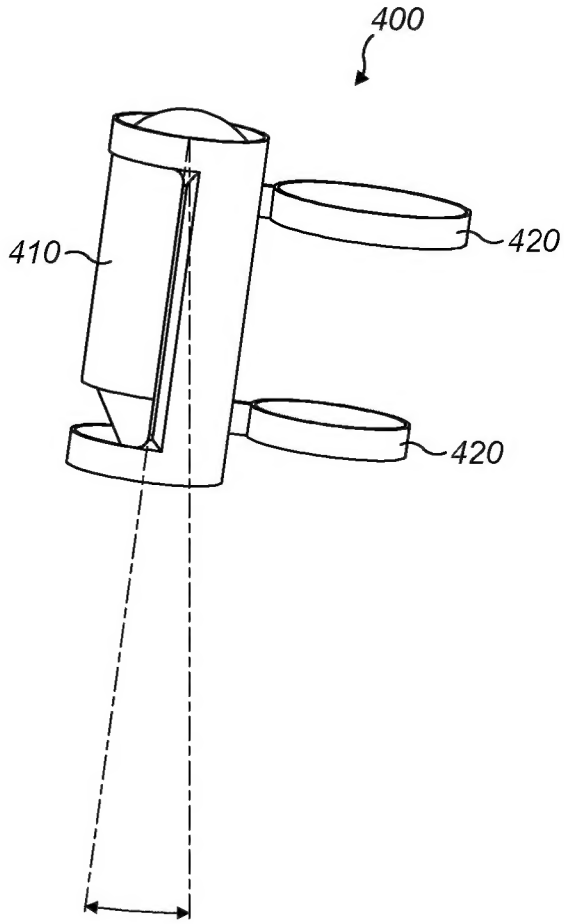

FIG. 4a

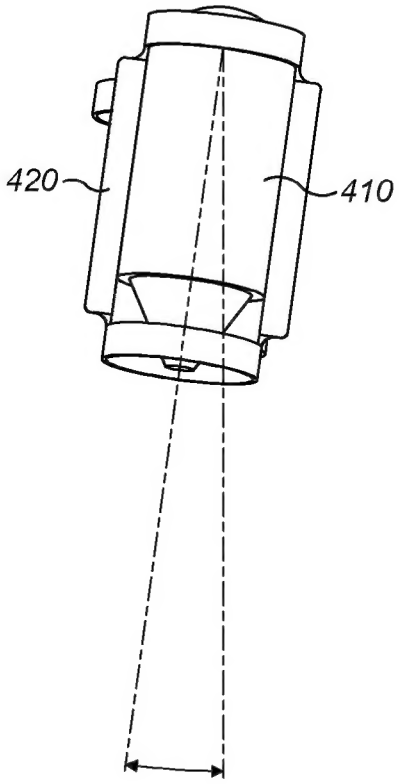

FIG. 4b

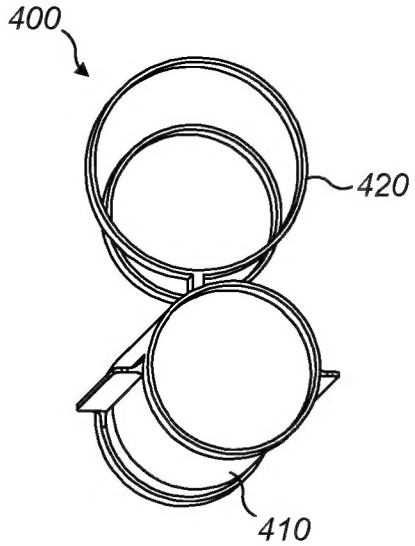

FIG. 4c

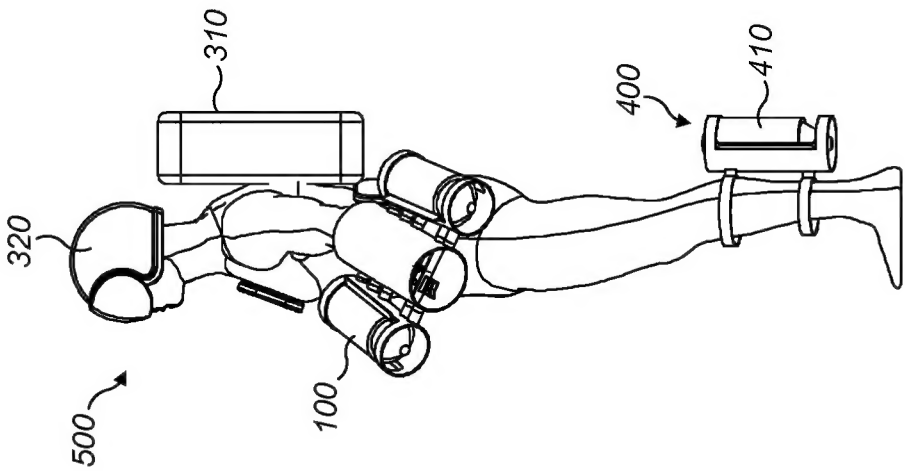

FIG. 5b

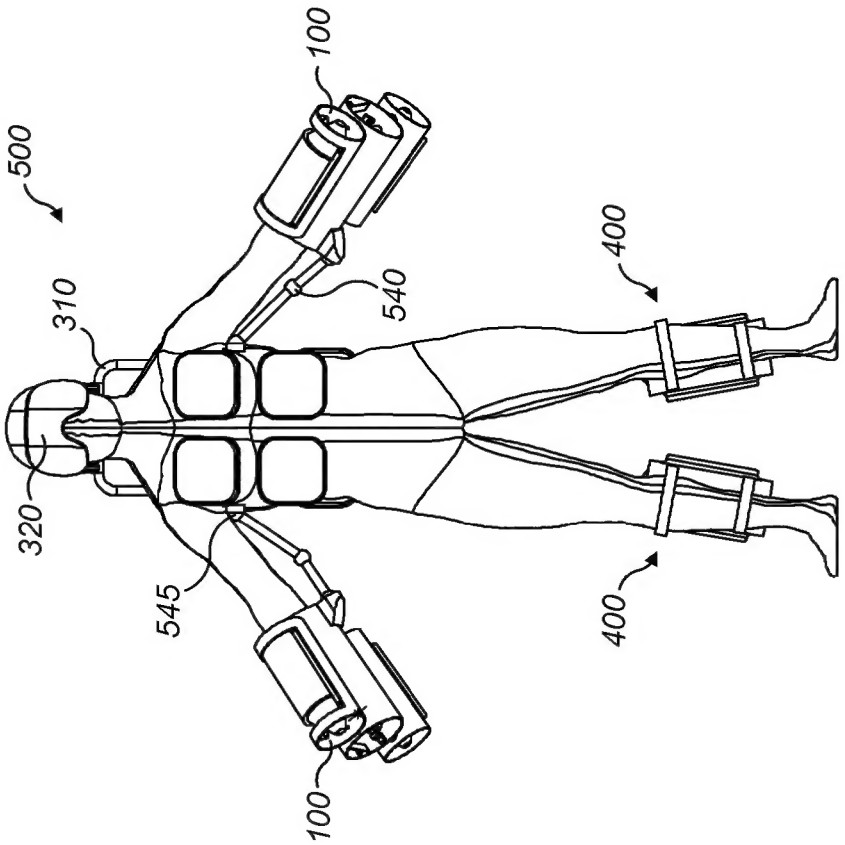

FIG. 5a

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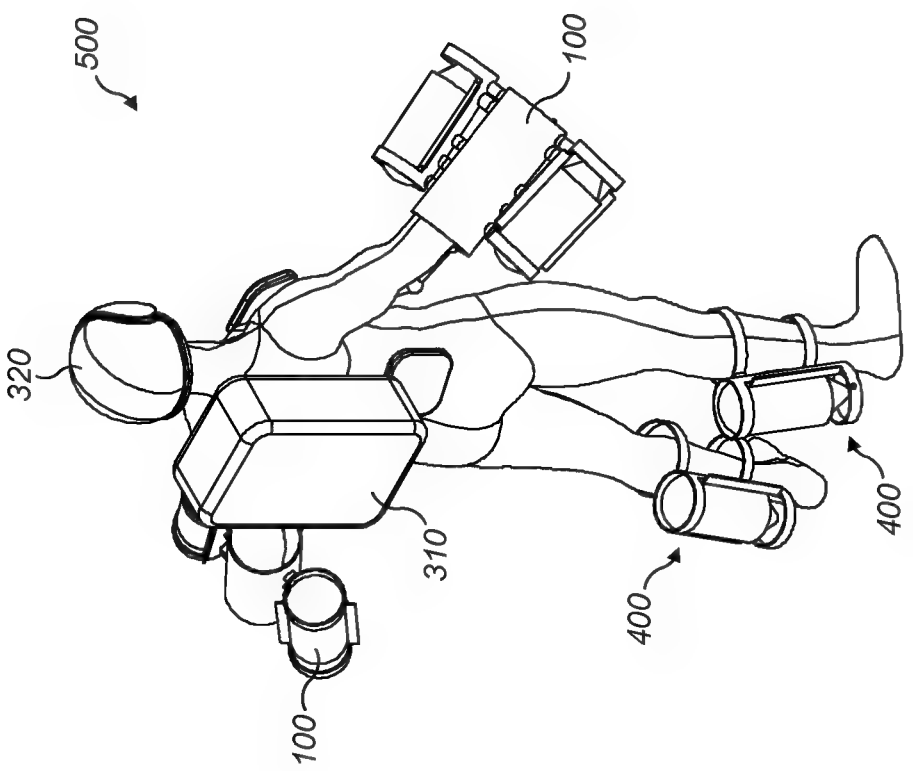

FIG. 5d

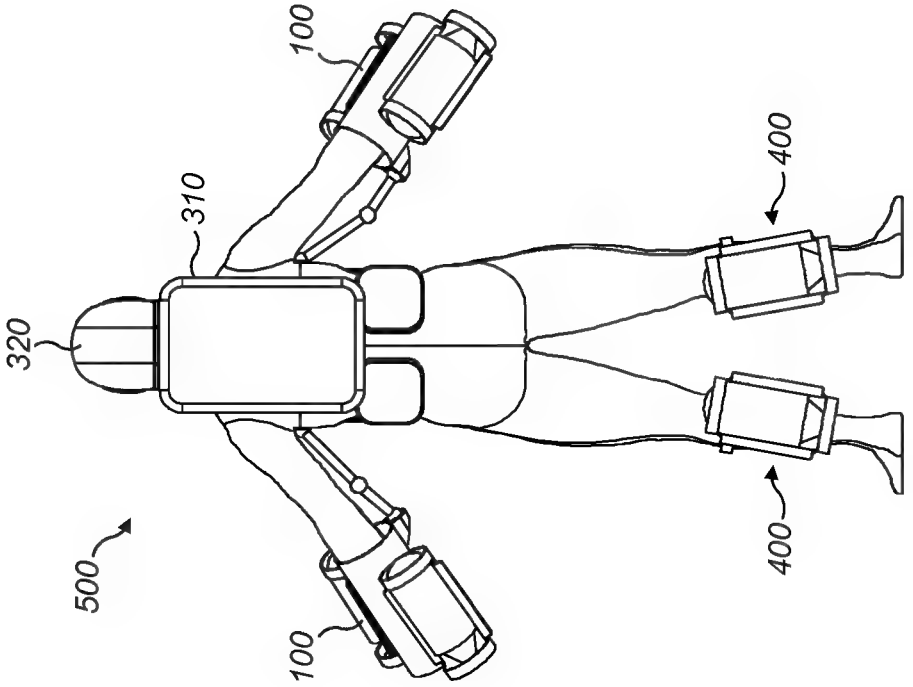

FIG. 5c

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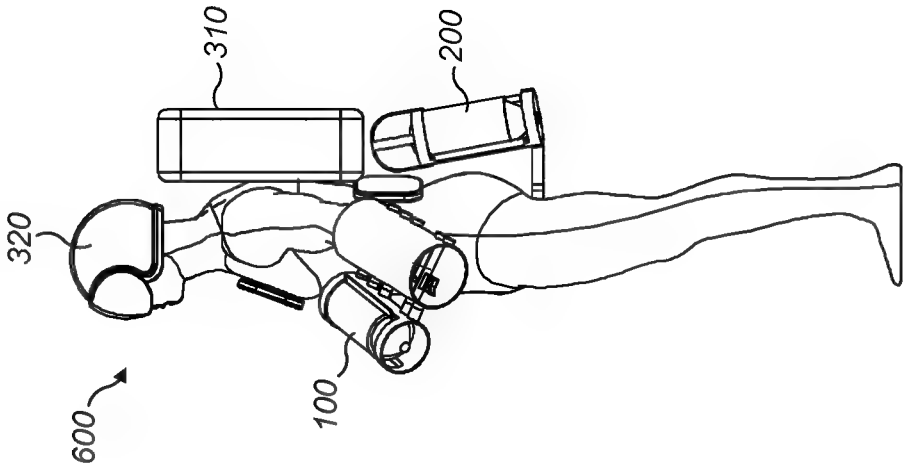

FIG. 6b

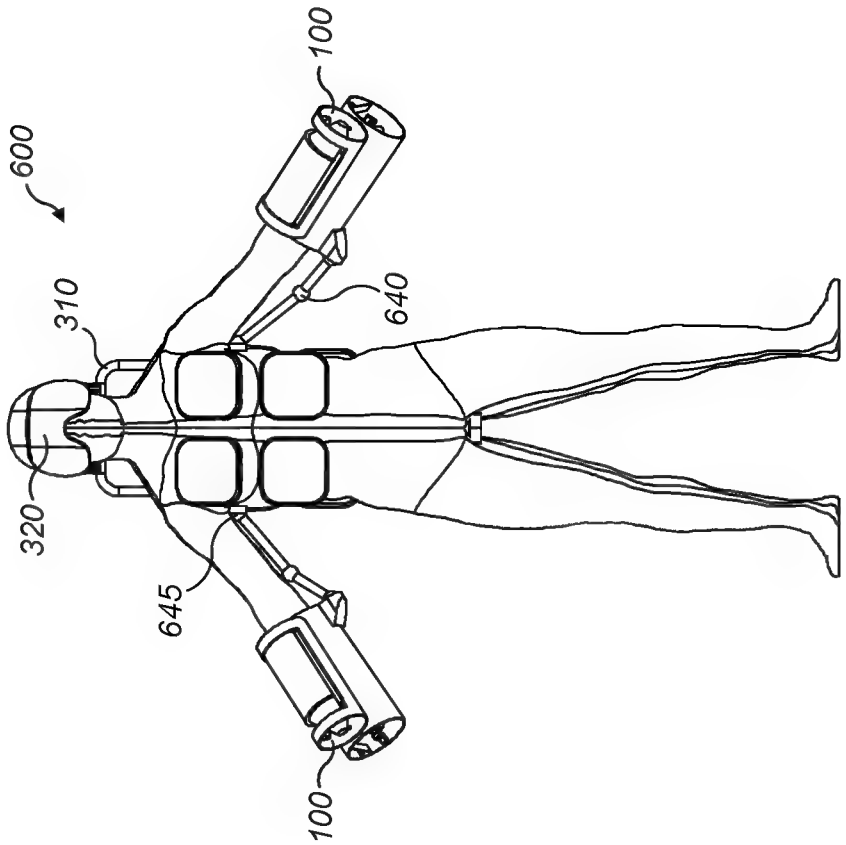

FIG. 6a

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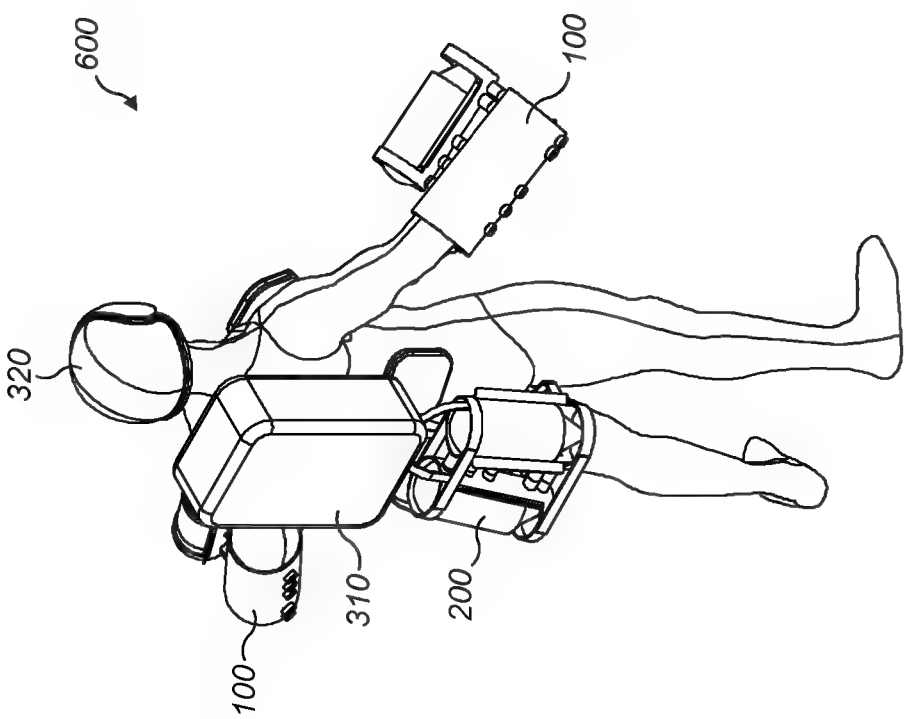

FIG. 6d

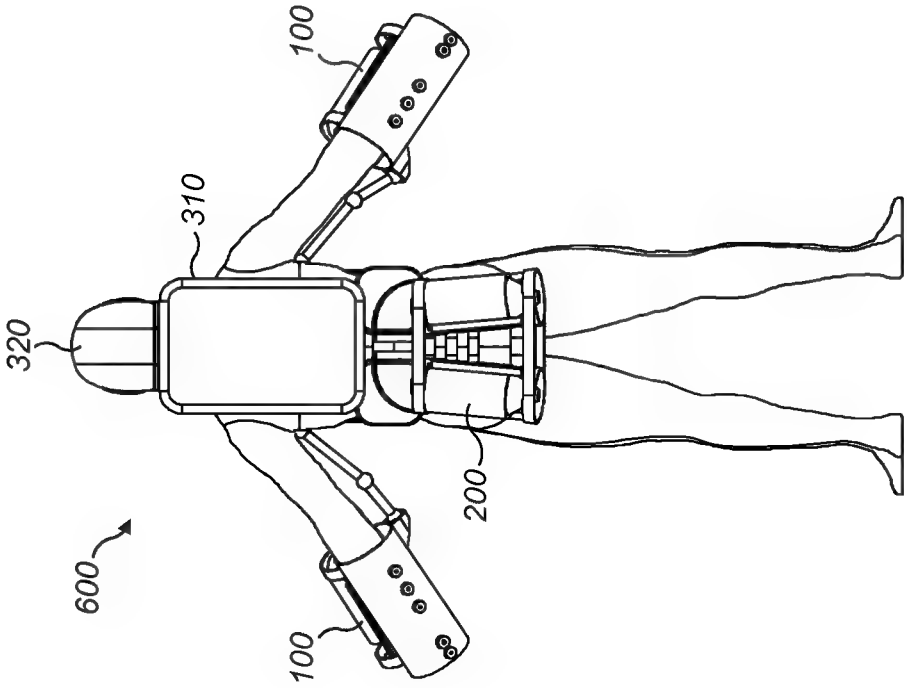

FIG. 6c

A FLIGHT SYSTEM

The invention relates to an apparatus for enabling an individual to fly. In particular, the invention relates to the provision of propulsion assemblies that can be held in a user's hands and/or worn on a user's forearms and provide thrust to lift the user from the ground.

There have been many attempts in the past to enable individuals to fly with only minimal equipment. Typically, such systems are formed of a framework that rigidly connects one or more propulsion units with each other or with a wing.

The inventors have realised that it is possible to configure a flight system that can use the strength of the human body, rather than a rigid frame work, to provide stable flight for an individual.

Accordingly, there is provided a wearable flight system and a propulsion assembly as defined by the claims.

By propulsion assembly is meant a device that produces thrust. A propulsion assembly may comprise one or more propulsion units that each provide thrust (for example, in a known direction) and collectively define the thrust that is produced by the propulsion assembly. The thrust provided by a propulsion assembly produces an equal and opposite force on the user. Preferably, each propulsion assembly is able to provide a maximum thrust of at least 400N and preferably at least 500N. Each propulsion assembly may be controllable to produce a lower thrust than the maximum based on control signals.

By "wearable" is meant that propulsion assemblies of the flight system (those parts that provide thrust) may be mounted on the human body such that the "wearer" contributes at least in part to the relative motion of those propulsion assemblies. That is, it is recognised that the difficult control problem of correctly angling a variety of thrusts produced by a plurality of propulsion assemblies may be delegated to the wearer's natural senses of balance, proprioception, and kinaesthesia.

Embodiments of the invention include a flight system comprising at least two propulsion assemblies that may be held in the hands and/or otherwise mounted on the wearer's forearms.

In such a system, net thrust is directed substantially in line with the user's respective forearm and away from the elbow so that the induced stress is generally aligned with the bones of the wearer's forearm and is directed outwardly. Here, reference is made to net thrust rather than all thrust. There may be multiple propulsion units that individually produce thrust that is not aligned with the wearer's arm, but collectively for each propulsion unit the net thrust (the resolution of the generated forces) will be so aligned.

A suitably physically conditioned wearer is able to support his/her own weight using just his/her arms, but for longer usage, it is preferable to share some of the load with other parts of the wearer's skeleton or musculature. Optionally, therefore, there may additionally be provided a body propulsion assembly arranged for engaging the wearer's torso to substantially prevent relative movement between the body propulsion assembly and the wearer's torso. In addition, or alternatively, one or more leg propulsion assemblies (either one for both legs or one for each leg) can be provided. The leg propulsion assemblies may be arranged for engaging one or both of the wearer's legs to substantially prevent relative movement between the leg propulsion assemblies and the wearer's corresponding leg(s).

In most preferred embodiments, however, half or the majority of the load is carried by the left-hand and right-hand propulsion assemblies collectively. In other words, the maximum thrust capability of the left-hand and right-hand propulsion assemblies together is preferably equal to or greater than the maximum thrust capability of the other propulsion assemblies combined.

In fact, it has been found that providing a thrust roughly equal between each of: the left-hand propulsion assembly; the right-hand propulsion assembly; and, collectively, the other propulsion assemblies, provides even more preferred stability (i.e., tripod-like balance between each arm and the body). Therefore, the maximum thrust capability of the left-hand and right-hand propulsion assemblies together are preferably equal and the maximum thrust capability of each of the left-hand and right-hand propulsion assemblies is preferably equal to or greater than the maximum thrust capability of the other propulsion assemblies combined.

Lift is produced by the combined vertical resolution of the forces generated by all of the propulsion assemblies. Whilst not essential, it is preferred for reasons of control and stability that the thrust generated by the left-hand and right-hand propulsion assemblies is equal. In order to control horizontal motion, the wearer can use his/her arms to direct the left-hand and right-hand propulsion assemblies to produce a net thrust that includes a horizontal component.

When a body propulsion assembly is provided, this may be inclined relative to the torso of the wearer (by virtue of the arrangement of a support through which it engages the wearer) so as to provide a small net forward force on the wearer, i.e. the thrust is directed rearwardly to produce a net force on the wearer in a forward direction perpendicular to a line extending between the centre of the user's head and the centre of the user's waist. In other words, with the wearer supported in an upright position, the body propulsion assembly may provide a net forward force. That forward force may be counteracted by the wearer inclining his/her arms in front of his/her torso to provide an equal net thrust in the opposite direction. Thus, the assemblies are arranged such that collectively they can produce equilibrium (a net vertical thrust equal to the load of the wearer and flight system, with a zero net horizontal thrust) when in a splayed (i.e. divergent) arrangement. Of

course, this also has the advantage that the exhaust of the propulsion assemblies is directed away from the wearer's body.

When a body propulsion assembly is provided, it is preferably arranged vertically at the same height as the left-hand and right-hand propulsion assemblies when in the splayed arrangement that produces equilibrium. It has been found that the preferred location on the body of the wearer is therefore slightly below the wearer's waist (that is, the thrust is generated slightly below the wearer's waist). Among other advantages, in the case that turbines or fans are used to provide thrust, this ensures that the air take in by one propulsion assembly is not fed by the outlet of another propulsion assembly.

In preferred embodiments, the propulsion assemblies configured to be worn on a user's hand or forearm may comprise at least two hand propulsion units in a splayed arrangement that produce thrusts that diverge such that their net thrust is substantially aligned with the wearer's arm. This has been found to add to the stability of the overall system.

The flight system of the invention may be provided with or without one or more wings. However, the features set out below make it unnecessary to use a wing and it is preferred that one is not possible.

For a better understanding of the invention, and to show how the same may be put into effect, reference will now be made, by way of example only, to the accompanying drawings in which:
Figures 1a to 1c show a first propulsion assembly for use in an embodiment of the invention;
Figures 2a to 2c show a second propulsion assembly for use in an embodiment of the invention;
Figures 3a to 3e show a first embodiment of a flight system in accordance with the invention;
Figures 4a to 4c show a third propulsion assembly for use in an embodiment of the invention;
Figures 5a to 5d show a second embodiment of a flight system in accordance with the invention; and
Figures 6a to 6d show a third embodiment of a flight system in accordance with the invention.

A first embodiment of a propulsion assembly 100 for applying thrust directly to a user's arm is shown in Figures 1a to 1c. Of course, it is intended that a flight system in accordance with the invention will have one propulsion assembly 100 for each arm.

With reference to Figure 1a, a propulsion assembly 100 comprises: one or more propulsion units 110; a sleeve 120; and one or more mountings 118.

In the depicted embodiment there are two propulsion units 110, a first propulsion unit 110a, and a second propulsion unit 110b. For the/each propulsion unit 110a, 110b, there is a mounting 118a, 118b via which the respective propulsion unit 110a, 110b may be mounted to the sleeve 120.

The sleeve 120 of the propulsion assembly 100 is configured to be worn on a user's hand and/or forearm. It is preferable that the sleeve 120 extends over a length of from 20cm to 50cm, and more preferably a length of from 30cm to 35cm, so that the propulsion assembly 100 is held in alignment with the user's arm, but does not hinder articulation of the elbow. The sleeve 120 defines a longitudinal axis, a distal end 121 and a proximal end 122. When the propulsion assembly 100 is worn, the distal end 121 is distal with respect to the user's body (e.g. nearer the user's hand) and the proximal end 122 is proximal with respect to the user's body (e.g. nearer the user's elbow). The sleeve 120 may have a diameter in the range 8cm to 10cm.

Preferably, the sleeve 120 is padded on the inside. The padding may be shaped to the general contour of an arm so as to distribute support comfortably.

Irrespective of the number of propulsion units 110, the propulsion assembly 100 as a whole is arranged to provide a net thrust along an axis that generally corresponds with the user's forearm when the propulsion assembly 100 is worn. That is, the propulsion assembly 100 as a whole is arranged to provide a net thrust along the longitudinal axis of the sleeve 120.

Preferably, the first and second propulsion units 110a, 110b are angled apart so as to produce thrust along non-parallel vectors. For example, the mountings 118a and 118b may include connecting members 130 that space the propulsion units 110a, 110b from the sleeve 120 by a greater amount at the distal end 121 than at the proximal end 122.

The first propulsion unit 110a is arranged to provide net force along a first axis Xa defining a first propulsion vector. The second propulsion unit 110b is arranged to provide net force along a second axis Xb defining a second propulsion vector.

It has been found that the divergence of thrust can provide beneficial stability. Preferably, therefore, the first propulsion vector is at least an angle of 5° relative to the second propulsion vector and more preferably at least an angle of 10°. Furthermore, it is preferable that the first propulsion vector is no more than an angle of 25° relative to the second propulsion vector and more preferably no more than 15°. By remaining within this range, the loss of thrust due to divergence can be balanced against the improved stability.

As best shown in Figure 1c, within the sleeve 120 there is provided a handle 124 for the user to grasp. The handle 124 may have mounted thereon controls 126. The controls 126 face the distal end 121 of the sleeve 120. In this way, when a portion of the user's weight is applied to the handle for support, the user's fingers will be free to manipulate the controls 126. Most preferably, the handle 124 is ergonomically-shaped so as to distribute the user's

weight over as large an area of the user's hand as possible. As a result, a left-hand propulsion assembly 100 may have a left-handed grip 124, while a right-hand propulsion assembly 100 may have a right-handed grip 124. One or both of the left-hand grip 124 and right-hand grip 124 will have controls 126 mounted thereon.

As in this embodiment, when first and second propulsion units 110a, 110b are provided, the handle is preferably positioned such that it is aligned with a line extending between the first and second propulsion units 110a, 110b. This defines the position of the first and second propulsion units 110a, 110b relative to the user's closed fist, and has been found to be particularly stable.

The controls 126 preferably comprise two input devices. The first of the input devices provides a variable signal and can be used to control an amount of thrust produced by a propulsion assembly 100 (or a set of propulsion assemblies 100). The second of the input devices provides a binary output and can be used to deactivate one or more or (preferably) all of the propulsion assemblies 100 of the flight system when released. It is not essential that both left-hand and right-hand propulsion assemblies 100 include the second input device, though this may be preferred. The second of the input devices is preferably a "kill switch". That is, it must remain depressed by the user in order to prevent deactivation of the propulsion assemblies 100.

Preferably, the controls 126 are mounted on the handle so as to align with the thumb and forefinger of the user. The first input device is therefore preferably in the form of a trigger aligned with the user's index finger (when the handle is held in the user's hand). The second input device is preferably aligned with the user's thumb (when the handle is held in the user's hand) so that it can be continually held down during use of the flight system to prevent deactivation.

A first embodiment of a propulsion assembly 200 for a user's torso is shown in Figures 2a to 2c. It is preferred that a flight system in accordance with the invention will have one such propulsion assembly 200.

Body propulsion assembly 200 is configured to apply thrust directly to a user's torso and comprises at least one body propulsion unit 210 and a support 220.

The support 220 is arranged to support a user's waist or torso. For example, it may comprise a seat, harness, belt, jacket, and/or other item of clothing for securing the at least one body propulsion unit 210 to a user's body. Preferably, the at least one body propulsion unit 210 is supported on the dorsal side of the user's body

The support may be configured to be worn on a user's back or waist, but in either case it is preferable that the support is sized and shaped such that the location at which thrust is generated by the at least one body propulsion unit(s) 210 (i.e. the nozzle of the body propulsion unit(s) 210 when these are turbines and/or the fan of a fan driven by a motor)

is located between the lower edge of the rib cage and knees, and most preferably level with the user's upper thigh.

The support 220 is arranged to hold the at least one body propulsion unit 210 at a fixed angle relative to the user's torso when the body propulsion assembly 200 is worn by (i.e. engages) the user. The support 220 defines an axis Z, which is parallel with a line extending between the centre of the user's head and the centre of the user's waist when the support is worn.

The support 220 holds the at least one body propulsion unit 210 at an angle to the axis Z. That angle has an elevation component, the body propulsion elevation angle W. That is, the body propulsion elevation angle W is the angle in the sagittal plane (the plane that divides the user into left and right sides) between the net thrust produced by the body propulsion assembly 200 and the axis Z.

In other words, the support 220 is configured to hold a user's body relative to the at least one body propulsion unit 210 such that a line extending between the centre of the user's head and the centre of the user's waist extends relative to the orientation of the net thrust provided by the body propulsion assembly 200 by the body propulsion elevation angle W.

The body propulsion elevation angle W is greater than zero. Preferably, the body propulsion elevation angle W is at least 10° and more preferably at least 12°. Even more preferably, the body propulsion elevation angle W is no more than 30° degrees and more preferably no more than 18°.

This choice of angle has been found to improve stability and protect the user's legs without greatly reducing total lift.

As can be best seen in Figures 2b and 2c, one optionally way of maintaining the body propulsion elevation angle W relative to the user's legs is by providing the support with leg braces 240 for engaging the user's upper thighs. A preferable leg brace 240 may comprise a section 244 arranged to extend between the user's legs so that the legs may grip the leg brace 240. The leg brace 240 may also have a wider section 242 on which a user may sit.

The body propulsion assembly 200 preferably includes at least a first body propulsion unit 210a and a second body propulsion unit 210b. The first body propulsion unit 210a is arranged to provide net force along a first axis Ya defining a first propulsion vector. The second body propulsion unit 210b is arranged to provide net force along a second axis Yb defining a second propulsion vector. The first propulsion vector is not parallel with the second propulsion vector. Preferably, the first and second propulsion vectors are directed apart by an angle of at least 5° and preferably at least 20°. Even more preferably, the first and second body propulsion vectors are directed apart by an angle of no more than 30°.

A first embodiment of a flight system is shown in Figures 3a to 3e, in which it can be seen that the system comprises a left-hand propulsion assembly 100 (of the type discussed

above with reference to Figures 1a to 1c); a right-hand propulsion assembly 100 (of the type discussed above with reference to Figures 1a to 1c); a body propulsion assembly 200 (of the type discussed above with reference to Figures 2a to 2c).

Preferably, each propulsion assembly 100, 200 is able to provide a maximum thrust in the range 400N to 500N.

Figures 3a to 3e show the preferred embodiment in which two propulsion units 110 are provided for each of the left-hand and right-hand propulsion assemblies 100. Also preferred is the provision of two propulsion units 210 for the body propulsion assembly 200. That is, a combination of six propulsion units 110, 210, with two for each arm and two for the user's torso. Also shown is the above-described preferred rearward orientation of the propulsion units 210 of the body propulsion assembly 200 when the user assumes an upright standing posture.

As discussed above, the support 220 of the body propulsion assembly 200 is sized and shaped to hold the body propulsion units 210 so that thrust is produced at a height between the lower edge of the rib cage and knees, and most preferably level with the user's upper thigh.

The flight system 300 also comprises an energy storage device 310 for providing power to the propulsion assemblies. This may comprise a fuel storage vessel for supplying fuel to turbines and/or batteries for powering fans and/or control circuitry. The energy storage device 310 is preferably provided in the form of a back-pack to be worn above a lower-back-mounted or waist-mounted body propulsion assembly 200.

Since the flight system 300 is preferably provided without a wing (i.e. it may be solely dependent upon the propulsion assemblies to provide lift), it is beneficial to minimise interruptions in the thrust provided by any one propulsion unit 110, 210, 410. One source of interruptions, in the case in which the propulsion assemblies comprise turbines, is the possibility of a bubble in the fuel line. This can potentially cause a momentary loss of thrust or even shut down the engine. It is preferable that when the energy storage device 310 comprises a fuel storage vessel, the vessel is provided as a variable volume storage (for example, a bladder or a cylinder closed by a piston) rather than a fixed volume chamber. In this way, no air will be present in the fuel storage vessel. 25. Preferable embodiments will comprise a bubble sensor for sensing the presence of bubbles in fuel supply lines for supplying fuel to turbines. The bubble sensor is for alerting the user to the presence of bubbles. In some embodiments, the bubble sensor may provide a bubble signal representative of an amount of bubbles (volume or number, etc.) in the fuel line. When the bubble signal exceeds a threshold, the user is alerted and may land, e.g. before the turbines fail. The alert may be audible or visual (for example using the head-up display described below).

A control system 330 is provided. This may be embodied in a single device to be worn on the user's chest, or may be formed with distributed devices. The control system 330 is

arranged to provide control signals to each propulsion assembly 100, 200. The control system 330 may also be arranged to receive control signals from each propulsion assembly 100, 200 and/or from the energy storage device 310.

Whilst the control system 330 may independently control the left-hand and right-hand propulsion assemblies 100, it is preferred that they each provide the same thrust.

Thus, in preferred embodiments the control signals may include: a first throttle signal generated by controls 126 of one of the left-hand and right-hand propulsion assemblies 100, and a second throttle signal generated by controls 126 of the other of the left-hand and right-hand propulsion assemblies 100. The control system 330 uses the first throttle signal to command the left-hand and right-hand propulsion assemblies 100 to each provide a corresponding first thrust. The control system 330 uses the second throttle signal to command the body propulsion assembly 200 to provide a second corresponding thrust.

As discussed above, the controls 126 may be embodied as one or two input devices the left-hand and right-hand propulsion assemblies 100. In each case, one of the input devices provides a variable signal in the form of the throttle signal. The other of the input devices (if provided) may be a "kill switch", which provides a binary output and is monitored by the control system 330 so as to deactivate one or more or (preferably) all of the propulsion assemblies 100 of the flight system when released.

The flight system preferably includes a helmet 320 which comprises a head-up display in communication with the control system 330. Preferably, the head-up display represents the amount of energy remaining in the energy storage device 310 (e.g., a volume of fuel remaining in the bladder) and/or the thrust of each of the propulsion assemblies 100, 200 (for example, the rotational speeds of the turbines).

Whereas, the flight system 300 of the first embodiment has been shown with a left-hand propulsion assembly 100, a right-hand propulsion assembly 100, and a body propulsion assembly 200, embodiments are envisaged in which the body propulsion assembly 200 is replaced by (as in the flight system 500 of Figures 5a to 5d), or supplemented with, a leg propulsion assembly 400 (either one for both legs, or one for each leg).

A leg propulsion assembly 400 comprises: at least one leg propulsion unit 410; and a support 420. The support 420 is preferably sized and shaped to be worn on a user's calf such that the at least one leg propulsion assembly 410 is on the dorsal side of the calf. The support 420 may comprise bindings for surrounding the user's leg such that the bindings define a longitudinal axis aligned with the bones of the lower leg.

It is preferred to have a single leg propulsion unit 410. The support 420 is preferably sized and shaped to be worn on a user's calf such that the leg propulsion unit 410 is at an angle V to the longitudinal axis of the support 420 (i.e. is not aligned with the bones of the lower leg). Preferably, angle V is such that when worn, there is a small force applied inwardly to press the user's legs towards one another. This provides divergence of thrust when a pair

of leg propulsion assemblies 400 are worn and has been found to improve stability. The support 420 is preferably arranged such that the leg propulsion unit 410 is at an angle to the longitudinal axis of the support 420 of at least 3°. More preferably, the support 420 is preferably arranged such that the leg propulsion unit 410 is at an angle to the longitudinal axis of the support 420 of no more than 20°. In this way, the leg propulsion units 410 at that angle to the user's leg when worn.

In the embodiments discussed above the left-hand and right-hand propulsion assemblies 100 each included two propulsion units 110. Whilst that is preferred, more may be provided, and in fact only one is required. Thus, there is envisaged an embodiment of a flight system 600 such as that shown in Figures 6a to 6d, in which each of the left-hand and right-hand propulsion assemblies 100 each included a single propulsion unit 110.

As can be seen from the Figures, in each embodiment of a flight system 300, 500, 600, the left-hand and right-hand propulsion assemblies are each connected to the body propulsion assembly via an articulated frame 340, 540, 640. This is merely optional, and in practice, a suitably trained individual can use the systems without such a frame.

However, a frame 340, 540, 640 is useful for less trained individuals to restrict the relative movement of the left-hand and right-hand propulsion assemblies 100. By providing a set of joints to articulate the frame 340, 540, 640, predetermined degrees of freedom may be provided. This can ensure that the left-hand and right-hand propulsion assemblies 100 will always be oriented in an appropriate direction (for example, the frame 340, 540, 640 can prevent an arm behind positioned behind the user's back).

The frame 340, 540, 640 would comprise composite materials and/or titanium. It may have a hinge under each armpit for allowing adduction or abduction of the arms, a rotational joint between the shoulder and elbow for allowing circumduction of the upper arm, a hinge on the elbow for allowing the arm to bend, another rotational joint between the elbow and wrist for allowing circumduction of the hand. Merely restricting the motion of the user in this way will help to support the load.

However, it may be preferable to use a control system having one or more gyros and/or accelerometers for controlling the frame 340, 540, 640 and the thrust applied by the propulsion assemblies 100, 200, 400. In which case, actuators 345, 545, 645 may be provided for actuating the articulated frame. The actuators 345, 545, 645, may be servos as drawn, or linear actuators (such as pneumatic or hydraulic actuators).

The actuators 345, 545, 645 may be controlled by the control system 330 to provide a force towards a position of stability (where horizontal components of the thrust are balanced) based upon signals from one or more gyros and/or accelerometers forming part of the system. As an example, this may be carried out using a PID controller to control the angles of the net thrust vectors produced by each propulsion assembly 100, 200, 400 so as to provide a predetermined net horizontal thrust (for example zero or a small positive thrust).

Each propulsion unit 110, 210, 410 produces thrust in a predetermined direction. As is known in the art, this may be achieved by accelerating air and/or combustion products in a longitudinal direction of the propulsion unit 110, 210, 410.

For example, each propulsion unit 110, 210, 410 may be a turbine. For example, a suitable turbine would be a JetCat turbine available from JetCat Germany, which is typically used in model aircraft or military drones.
Alternatively, a ducted fan driven by an electric motor may be used as a propulsion unit 110, 210, 410. If it is required that the system may fly for an extended period, it is possible that the power supply could be connected via a long cable and so need not be carried, thereby reducing the load for the fans.

Whilst the divergent propulsion units of each propulsion assembly are preferably individual turbines (or ducted fans), it is envisaged that the divergent thrusts may be achieved using a single turbine having two or more exhaust nozzles that themselves diverge by the preferable stabilising angles.

Furthermore, whilst wings are not needed for the flight system to fly, these may additionally be provided. For example, a suit forming part of the flight system may comprise a membrane extending between the arms and the side of the body, or a membrane extending between the legs. Alternatively (or additionally) a rigid wing shaped to provide lift may be worn on the user's back.

CLAIMS:

1. A wearable flight system comprising a plurality of propulsion assemblies including a left-hand propulsion assembly configured to be worn on a user's left hand and/or forearm and a right-hand propulsion assembly configured to be worn on a user's right hand and/or forearm.

2. The system of claim 1, wherein each of the left-hand and right-hand propulsion assemblies are arranged to be worn such that in use net thrust is directed substantially in line with the user's respective forearm and away from the elbow.

3. The system of claim 1 or claim 2, further comprising a body propulsion assembly comprising a support for supporting a user's waist or torso.

4. The system of claim 3, wherein the support of the body propulsion assembly is configured to hold the user's body such that a line extending between the centre of the user's head and the centre of the user's waist extends relative to the orientation of the net force provided by the body propulsion assembly in use by a body propulsion elevation angle, the body propulsion elevation angle being greater than zero.

5. The system of claim 4, wherein the body propulsion elevation angle is at least 10^{o}.

6. The system of claim 4 or claim 5, wherein the body propulsion elevation angle is no more than 30^{o}.

7. The system of any one of claims 4 to 6, wherein the support is configured to be worn on a user's back or waist and the support is connected to the body propulsion assembly such that the body propulsion assembly is located below the user's waist.

8. The system of any one of claims 3 to 7, wherein the left-hand and right-hand propulsion assemblies collectively are arranged to provide maximum thrust in excess of the maximum thrust of the body propulsion unit.

9. The system of any one of claims 3 to 8, further comprising first and second throttle controls, wherein the first throttle control is arranged to control the thrust provided by both the left-hand and right-hand propulsion assemblies, and the second throttle control is arranged to control the thrust provided by the body propulsion assembly.

10. The system of any preceding claim, wherein the left-hand and right-hand assemblies each comprise means for providing a first thrust along an axis defining a first hand propulsion vector and a second thrust along an axis defining a second hand propulsion vector.

11. The system of any preceding claim wherein the left-hand and right-hand assemblies each comprise at least first and second hand propulsion units, the first hand propulsion

unit arranged to provide net force along an axis defining a first hand propulsion vector, the second hand propulsion unit arranged to provide net force along an axis defining a second hand propulsion vector.

12. The system of claim 10 or claim 11, wherein the first hand propulsion vector is not parallel with the second hand propulsion vector.

13. The system of claim 12, wherein the first and second hand propulsion vectors are directed apart by an angle of at least 5°.

14. The system of claim 10 or claim 13, wherein the first and second hand propulsion vectors are directed apart by an angle of no more than 25°.

15. The system of any one of claims 11 to 12, wherein the two hand propulsion units are arranged either side of a sleeve in which is mounted a handle to be held by a user.

16. The system of claim 15, wherein a longitudinal axis of each of the two hand propulsion units and the sleeve lie in a plane.

17. The system of any one of claims 3 to 16, wherein the body propulsion assembly comprises means for providing a first thrust along an axis defining a first body propulsion vector and a second thrust along an axis defining a second body propulsion vector, wherein the first body propulsion vector is not parallel with the second body propulsion vector.

18. The system of any one of claims 3 to 17, wherein:

the body propulsion assembly comprises at least two body propulsion units;

a first body propulsion unit is arranged to provide net force along an axis defining a first body propulsion vector;

a second body propulsion unit of the body propulsion assembly arranged to provide net force along an axis defining a second body propulsion vector; and

the first body propulsion vector is not parallel with the second body propulsion vector.

19. The system of claim 17 or 18, wherein the first and second body propulsion vectors are directed apart by an angle of at least 10°.

20. The system of any one of claims 17 to 19, wherein the first and second body propulsion vectors are directed apart by an angle of no more than 30°.

21. The system of any preceding claim, further comprising a left-leg propulsion assembly configured to be worn on a user's left leg and a right-leg propulsion assembly configured to be worn on a user's right leg.

22. The system of any preceding claim, wherein the propulsion assemblies comprise turbines and/or ducted electric fans.

23. The system of any preceding claim, wherein the left-hand, right-hand, and body propulsion assembly comprises turbines.

24. The system of claim 23, comprising left-leg and right-leg propulsion assemblies that comprise ducted electric fans.

25. The system of any preceding claim, wherein the left-hand and right-hand propulsion assemblies are arranged to provide a maximum combined thrust of at least 800N .

26. The system of any one of claims 3 to 25, wherein the body propulsion assembly is arranged to provide a maximum thrust of at least 400N.

27. The system of any preceding claim, further comprising an inflatable bladder for storing fuel in communication with at least one of the propulsion assemblies via a fuel supply line.

28. The system of claim 27, further comprising a bubble sensor for sensing the presence of bubbles in the fuel supply line for alerting the user to the presence of bubbles.

29. The system of any preceding claim, wherein the left-hand and right-hand propulsion assemblies are freely movable relative to each other.

30. The system of any one of claims 3 to 28, wherein the left-hand and right-hand propulsion assemblies are each connected to the body propulsion assembly via an articulated frame whereby the left-hand and right-hand propulsion assemblies are movable relative to the body propulsion assembly with predetermined degrees of freedom.

31. The system of any one of claims 30, further comprising actuators for actuating the articulated frame.

32. The system of any preceding claim, not comprising a wing.

33. The system of any preceding claim, wherein the propulsion assemblies are connected to a controller, arranged to control the thrust generated by each propulsion assembly.

34. The system of any one of claims 3 to 33, wherein the body propulsion assembly, the left-hand propulsion assembly, and the right-hand propulsion assembly each have the same number of propulsion units.

35. The system of any preceding claims wherein the plurality of propulsion assemblies includes a left-leg propulsion assembly configured to be worn on a user's left leg and a right-leg propulsion assembly configured to be worn on a user's right leg.

36. The system of claim 35, wherein the leg propulsion assemblies each comprise:

a leg propulsion unit arranged to provide net force along an axis defining a leg propulsion vector; and

a support for engaging the wearer's leg, the support defining a support axis that is in parallel with the user's leg when the leg propulsion assembly is worn,

wherein the support is arranged such that the leg propulsion vector is not parallel with the support axis.

37. The system of claim 36, wherein the leg propulsion vector is at an angle from the support axis by at least 3°.

38. The system of claim 36 or claim 37, wherein the leg propulsion vector is at an angle from the support axis by no more than 20°.

39. A propulsion assembly configured to be worn on a user's hand and/or forearm, comprising means for providing a first thrust along an axis defining a first hand propulsion vector and a second thrust along an axis defining a second hand propulsion vector, wherein the first hand propulsion vector is not parallel with the second hand propulsion vector.

40. A propulsion assembly configured to be worn on a user's hand and/or forearm, comprising at least first and second hand propulsion units, the first hand propulsion unit arranged to provide net force along an axis defining a first hand propulsion vector, the second hand propulsion unit arranged to provide net force along an axis defining a second hand propulsion vector, wherein the first hand propulsion vector is not parallel with the second hand propulsion vector.

41. The assembly of claim 39 or claim 40, wherein the first and second hand propulsion vectors are directed apart by an angle of at least 5°.

42. The assembly of any one of claims 39 to 41, wherein the first and second hand propulsion vectors are directed apart by an angle of no more than 25°.

43. The assembly of any one of claims 39 to 42, wherein the two hand propulsion units are arranged either side of a sleeve in which is mounted a handle to be held by a user's hand.

44. The assembly of claim 43, wherein a longitudinal axis of each of the two hand propulsion units and the sleeve lie in a plane.

45. A body propulsion assembly configured to apply thrust to a user's torso, comprising:

a body propulsion unit arranged to provide net force along an axis defining a net body propulsion vector; and

a support for supporting a user's waist or torso,

wherein the support is configured to hold a user's body relative to the body propulsion unit such that a line extending between the centre of the user's head and the centre of the user's waist extends relative to the orientation of the net body propulsion vector in use by a body propulsion elevation angle, the body propulsion elevation angle being greater than zero.

46. The assembly of claim 45, wherein the body propulsion elevation angle is at least 10°.

47. The assembly of claim 45 or claim 46, wherein the body propulsion elevation angle is no more than 30°.

48. The assembly of any one of claims 45 to 47, wherein the support is configured to be worn on a user's back or waist and the support is connected to the body propulsion assembly such that the body propulsion assembly is located below the user's waist.

49. The assembly of any one of claims 45 to 48, wherein the support comprises leg braces for engaging the user's upper thighs.

50. The assembly of any one of claims 45 to 49, comprising means for providing a first thrust along an axis defining a first body propulsion vector and a second thrust along an axis defining a second body propulsion vector, wherein the first body propulsion vector is not parallel with the second body propulsion vector.

51. The assembly of any one of claims 45 to 49, further comprising at least two body propulsion units, wherein:

a first body propulsion unit is arranged to provide net force along an axis defining a first body propulsion vector;

a second body propulsion unit of the body propulsion assembly arranged to provide net force along an axis defining a second body propulsion vector; and

the first body propulsion vector is not parallel with the second body propulsion vector.

52. The assembly of claim 51, wherein the first and second body propulsion vectors are directed apart by an angle of at least 5°.

53. The assembly of claim 51 or claim 52, wherein the first and second body propulsion vectors are directed apart by an angle of no more than 30°.

Amendment to the claims have been filed as follows

CLAIMS:

1. A wearable flight system comprising a plurality of propulsion assemblies including a left-hand propulsion assembly configured to be worn on a user's left hand and/or forearm and a right-hand propulsion assembly configured to be worn on a user's right hand and/or forearm, the wearable flight system further comprising a body propulsion assembly comprising a support for supporting a user's waist or torso.

2. The system of claim 1, wherein each of the left-hand and right-hand propulsion assemblies are arranged to be worn such that in use net thrust is directed substantially in line with the user's respective forearm and away from a corresponding elbow of that arm.

3. The system of claim 1 or 2, wherein the support of the body propulsion assembly is sized and shaped to hold the user's body such that a line extending between a centre of the user's head and a centre of the user's waist extends relative to the orientation of the net force provided by the body propulsion assembly in use by a body propulsion elevation angle, the body propulsion elevation angle being greater than zero.

4. The system of claim 3, wherein the body propulsion elevation angle is at least 10^{o}.

5. The system of claim 3 or claim 4, wherein the body propulsion elevation angle is no more than 30^{o}.

6. The system of any one of claims 3 to 5, wherein the support is configured to be worn on a user's back or waist and the support is connected to the body propulsion assembly such that the body propulsion assembly is located below the user's waist.

7. The system of any one of claims 2 to 6, wherein the left-hand and right-hand propulsion assemblies collectively are arranged to provide maximum thrust in excess of the maximum thrust of the body propulsion unit.

8. The system of any one of claims 2 to 7, further comprising first and second throttle controls, wherein the first throttle control is arranged to control the thrust provided by both the left-hand and right-hand propulsion assemblies, and the second throttle control is arranged to control the thrust provided by the body propulsion assembly.

9. The system of any preceding claim, wherein the left-hand and right-hand assemblies each comprise means for providing a first thrust along an axis defining a first hand propulsion vector and a second thrust along an axis defining a second hand propulsion vector.

10. The system of any preceding claim wherein the left-hand and right-hand assemblies each comprise at least first and second hand propulsion units, the first hand propulsion unit arranged to provide net force along an axis defining a first hand propulsion vector, the

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second hand propulsion unit arranged to provide net force along an axis defining a second hand propulsion vector.

11. The system of claim 9 or claim 10, wherein the first hand propulsion vector is not parallel with the second hand propulsion vector.

12. The system of claim 11, wherein the first and second hand propulsion vectors are directed apart by an angle of at least 5°.

13. The system of claim 9 or claim 12, wherein the first and second hand propulsion vectors are directed apart by an angle of no more than 25°.

14. The system of any one of claims 10 to 11, wherein the two hand propulsion units are arranged either side of a sleeve in which is mounted a handle to be held by a user.

15. The system of claim 14, wherein a longitudinal axis of each of the two hand propulsion units and the sleeve lie in a plane.

16. The system of any one of claims 2 to 15, wherein the body propulsion assembly comprises means for providing a first thrust along an axis defining a first body propulsion vector and a second thrust along an axis defining a second body propulsion vector, wherein the first body propulsion vector is not parallel with the second body propulsion vector.

17. The system of any one of claims 2 to 16, wherein:

the body propulsion assembly comprises at least two body propulsion units;

a first body propulsion unit is arranged to provide net force along an axis defining a first body propulsion vector;

a second body propulsion unit of the body propulsion assembly arranged to provide net force along an axis defining a second body propulsion vector; and

the first body propulsion vector is not parallel with the second body propulsion vector.

18. The system of claim 16 or 17, wherein the first and second body propulsion vectors are directed apart by an angle of at least 10°.

19. The system of any one of claims 16 to 18, wherein the first and second body propulsion vectors are directed apart by an angle of no more than 30°.

20. The system of any preceding claim, wherein the propulsion assemblies comprise turbines and/or ducted electric fans.

21. The system of any preceding claim, wherein the left-hand, right-hand, and body propulsion assembly comprises turbines.

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22. The system of claim 21, comprising left-leg and right-leg propulsion assemblies that comprise ducted electric fans.

23. The system of any preceding claim, wherein the left-hand and right-hand propulsion assemblies are arranged to provide a maximum combined thrust of at least 800N .

24. The system of any one of claims 2 to 23, wherein the body propulsion assembly is arranged to provide a maximum thrust of at least 400N.

25. The system of any preceding claim, further comprising an inflatable bladder for storing fuel in communication with at least one of the propulsion assemblies via a fuel supply line.

26. The system of claim 25, further comprising a bubble sensor for sensing the presence of bubbles in the fuel supply line for alerting the user to the presence of bubbles.

27. The system of any one of claims 2 to 26, wherein the left-hand and right-hand propulsion assemblies are each connected to the body propulsion assembly via an articulated frame whereby the left-hand and right-hand propulsion assemblies are movable relative to the body propulsion assembly with predetermined degrees of freedom.

28. The system of any one of claims 27, further comprising actuators for actuating the articulated frame.

29. The system of any preceding claim, wherein the propulsion assemblies are connected to a controller, arranged to control the thrust generated by each propulsion assembly.

30. The system of any one of claims 2 to 29, wherein the body propulsion assembly, the left-hand propulsion assembly, and the right-hand propulsion assembly each have the same number of propulsion units.

31. The system of any preceding claims wherein the plurality of propulsion assemblies includes a left-leg propulsion assembly configured to be worn on a user's left leg and a right-leg propulsion assembly configured to be worn on a user's right leg.

32. The system of claim 31, wherein the leg propulsion assemblies each comprise:

a leg propulsion unit arranged to provide net force along an axis defining a leg propulsion vector; and

a support for engaging the wearer's leg, the support defining a support axis that is in parallel with the user's leg when the leg propulsion assembly is worn,

wherein the support is arranged such that the leg propulsion vector is not parallel with the support axis.

33. The system of claim 32, wherein the leg propulsion vector is at an angle from the support axis by at least 3°.

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34. The system of claim 32 or claim 33, wherein the leg propulsion vector is at an angle from the support axis by no more than 20°.

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Application No:	GB1702852.3	**Examiner:**	Mr Keir Howe
Claims searched:	1-38	**Date of search:**	27 July 2017

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1, 2, 21-25, 27-29, 32, 33, 35	Marvel Studios, "Iron Man", released 2008, distributed by Paramount Studios. Note in particular character Tony Starks's use of a wearable flight system utilising propulsion units worn on the hands.
X	1, 2, 29, 32, 33	US3107069 A (DRAIM) See figures in particular, noting propulsion units 18 worn on the user's hands providing propulsion during space flight.
X	1, 2, 22, 23, 29, 32, 33	US2015/158567 A1 (ZAPATA) See figure 1 in particular, noting propulsion units 13 worn on the users forearm, providing propulsion during flights over bodies of water.
A	-	US2008/142644 A1 (O'ROARK) See figures in particular, noting wearable flight system utilising motors movable by user's arms.
A	-	US4040577 A (MOORE) See figures 1 and 2 in particular, noting wearable flight system utilising turbo jet engines 10, 12.
A	-	JP2006297554 A (TAISEI CORP) see figures 6 to 8 in particular noting ducted fans used for flight located on arms of the exoskeleton.
A	-	US2015/210389 A1 (MURDOCK) See figure 38 in particular, noting wearable flight system with propulsion provided by wings moved by user's arms.
A	-	US4253625 A (DMITROWSKY) See figures in particular, noting wearable flight system utilising a propulsion system located about the user's waist.
A	-	AU 2007100576 A4 (READ) See figure 1 in particular, noting propulsion unit 1 worn at an angle around user's waist or torso for propulsion through water.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of	P	Document published on or after the declared priority date but before the filing date of this invention.

	same category.		
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[X] :

Worldwide search of patent documents classified in the following areas of the IPC

B64C; B64G

The following online and other databases have been used in the preparation of this search report

WPI; EPODOC

International Classification:

Subclass	Subgroup	Valid From
B64C	0015/02	01/01/2006
B64C	0039/02	01/01/2006